REMARKS

Claims 1-20 remain in the application. As discussed during the interview, claims 1 and 3 have been amended to recited that the water glass is in soluble form (as opposed to a powder form-see Ljungbo).

Claims 1-20 were rejected under 35 U.S.C. 112, second paragraph. This rejection is traversed.

As originally filed the application indicated a "dry method". Upon the first action in the case, the claim was amended to refer to "a stream of air" based on comments made in the first office action. Based on the comments made in the second office action, the language was returned to "dry method". As noted in the last amendment, Ljungbo uses the term "dry method" (see title). As noted above, "dry method" is an art recognized term. See also the concurrently filed declaration of Volker Thole. As such, claim 1 should comply with the requirements of 35 U.S.C. 112, second paragraph.

Background Information:

Dry method

The term "dry method" is a well known technical term in the fiberboard industry. There is a standard (DIN EN 316), giving a definition of the dry method. The term dry method relates not to the process of adding binders such as resin and the like , but to the process of building up a so called "fiber cake". In the dry method, the chopped wood particles are conveyed into a heating device of a refiner in which they are treated at temperatures between 140°C to 190°C for 3-8 minutes. The heating or cooking takes place under presence of water. Subsequently, the soaked and softened chopped wood particles are conveyed to a fiber mill (refiner), where they are dispersed. The high pressure inside the refiner conveys the dispersed fibers in a connection line, the so-called "blow-line", between the refiner and a dryer. Normally, the adding of the binders or resins takes place in this blow-line. Because of this, this kind of adding of the binders is called "blow-line-blending". This method is advantageous especially in regard to the distribution of binders. No other known industrial method is able to provide as good and homogenous distribution of the binders. The fibers, mixed with binders,

are conveyed into a dryer and are dried within seconds, having a remaining liquid content of 8-12% (at least less than 20%).

In all methods to produce products from wood particles or wood fibers, the fibers have to be arranged in a fiber cake. It is very important that there are no agglomerates inside the distribution of the fibers. To achieve this, the fibers are broken up as much as possible and isolated or singularized as much as possible. The dry fibers fall onto a conveyer belt. Because of the very loose condition of the fibers, the raw density of the fiber cake is very low. The initial height of the fiber cake for a fiberboard of a thickness of 16 mm is more than 500 mm. In modern fiberboard plants the compression takes place by continuously working presses. Because of the low water content, a specific press time between 5-10 seconds per millimeter plate thickness can be realized.. This means an overall press time of 160 seconds for a board with a thickness of 16mm. To bind the fibers to each other in the dry method, binding substances are required to be added (binders are necessary, without binders, no usable fiberboard can be produced). Normally, organic binders are used.

Wet Method

The wet method is based on fibers produced in a refiner, also. In contrast to the dry method, the fibers are not dried, but are mixed in a mixer with additional water to a fiber suspension. The solids content in this solution after adding additional water is about 2%. Forming of a fiber cake takes place by spilling the fiber suspension onto a vacuum suction device and by additional dewatering via a press device. The forming of the plates takes place in a heat press. The specific press time is very long because the water content is significantly higher than 20%. The long press time is necessary to evaporate the remaining water in the fiber cake. The fiber boards obtained with the wet method can be produced without adding any binder. The binding of fibers takes place because of auto-adhesive processes in which some parts of the wood, lignin for example, develop binding qualities in combination with thermal energy.

In view of the above, it should be recognized that in the fiberboard industry, the dry method and the wet method are recognized as being fundamentally different from each other. Because of this, fiberboards are classified inter alia by the way in which they were produced. As noted in the

attached computer printout from www.wpif.org.uk/pg/43_annex2ev2.pdf, the classification between the wet method and dry method is understood worldwide. Furthermore, the following US and PCT Patents specifically discuss the use of the wet method in preparing fiberboard: U.S. Patent 4,221,630; WO/1983,001637, and the following US Patents specifically discuss the use of the dry method in preparing fiberboard: U.S. Patent 5,034,175; U.S. Patent 4,311,555; U.S. Patent 4,207,043

Adding of a binder and water glass

The adding of fibers during the production of MDF (by dry method) takes place before the fibers are conveyed to the dryer. For the wet method, binders are not necessary. The adding of water glass in the wet method is not effective. If the fiberboards are produced according to the dry method, it is possible to add the binders after drying of the fibers, but this is disadvantageous. Fibers for MDF have a very low bulk density of about 100 kg/m^3. The density of the binders is about 1000 kg/m^3. Under the assumption of the usual binder content of 10-15%, a small volume of binder has to be mixed intensively with a big volume of fibers. With normal dry mixers this is not possible. Furthermore, fibers tend to agglomerate to each other upon adding of binders. There are fiber agglomerates in the dry mix process with very high binder content at the surface of the agglomerates and very low binder content on the inner part of the agglomerates.

MDF made of such fibers is characterized by a very inhomogenous distribution of binders and low mechanical and low hydrophobic or hydroscopic properties. Furthermore, such fiber boards have spots on the surface of the plates affecting the coating ability adversely. The same negative properties are detected when adding water glass in the dry mixer.

With adding of water glass the inflammability of the fiberboard should be reduced. To achieve a low inflammability, it is crucial that there is a homogenous distribution of water glass in the fiberboards. If there is an inhomogenous distribution of water glass, the flame retarding effect is significantly lower than with homogenous distribution. Because of this, it is better to add water in the blow-line and prior to the drying of the fibers than to add water glass in the dry mixer.

How to add water glass

Water glass can be added advantageously as a solution because powder tends to sediment, which would result in an inhomogenous distribution perpendicular to the main surfaces of the fiber cake and the fiber board.

Because of the fact that the press time depends on the water content of the fiber cake, the water content should not increase 11%. Assuming the normal solid content of a water glass solution and the amount of water glass necessary for the required inflammability, there is a significantly higher water content than 11% if the dry mixing is carried out. If the water glass is added in the blow-line, as contemplated in the claimed invention, the aforementioned disadvantage is not present since, regardless of the water content added in the blow-line after drying, the fibers are always in the required state regarding the water content. The water glass dries together with the fibers in the fiber drier.

Surprising effect

Normally dried water glass becomes a powder and should sediment during the dispersing of the fibers onto the press band. Surprisingly, this is not the case by adding the water glass solution in the blow line, as is set forth in the claimed invention. Because of the heat in the blow line blending, the ability to bind or the so called tak of the water glass is activated. After the drying process there is a fiber mixture with adherences of water glass, and a sedimentation cannot take place anymore.

See also the declaration of Volker Thole.

Claims 1-10 and 13-19 were rejected as being obvious over Ljungbo in view of DE 1127270 to Gath and U.S. Patent Publication 2002/0100996 to Moyes. Claims 11, 12 and 20 were rejected as being obvious over Ljungbo, Gath, Moyes and DE 19500653 to Nurnberger. These rejections are traversed.

The conclusion of the Examiner that each step recited in the claims is taught in the combination of references is simply incorrect. The Examiner is correct in stating that no single reference is required to teach or suggest every feature of the claim, and that a teaching reference can be invoked because it suggest or teaches specifically certain features for which it is cited. However, it is incorrect to cite references for a feature when the reference actually teaches away from the use proposed in the current invention.

Regarding claims 1 - 4, each require that inorganic materials based on

potassium and/or sodium silicates (water glass) are added to the fibrous materials, then a cake of the mixture is formed, and then the cake is compressed. Ljungbo specifically teaches away from the addition of water glass "tests have also been made with waterglass...but these solutions bring about such difficult disturbances in the process- aggregation to fibre bundles or balls with poor binding to other fibers or poor though glueing- that no acceptable results have been achieved that way" (page 1 para 5). Claims 1 and 3 have also been amended to recite the use of water glass in soluble form, and this is not taught in Ljungbo.

The order of the steps in the method claims 1 and 3 impart a patentable distinction from the cited references, by producing unexpected results. Normally dried water glass becomes a powder and should sediment during the dispersing of the fibers onto the press band. Surprisingly, this is not the case by adding the water glass solution in the blow line, as is set forth in the claimed invention. Because of the heat in the blow line blending, the ability to bind or the so called tack of the water glass is activated. After the drying process there is a fiber mixture with adherence from the water glass, and a sedimentation cannot take place anymore.

The Examiner argues that it would have been obvious to one of ordinary skill in the art to use the claimed mixing and curing temperatures taught by the Gath reference because the ranges overlap with the ranges recited in the claims. The Gath reference teaches the formation of porous molded elements containing fibers and alkali silicates that are sprayed in a foam into a desired mold. The temperature range is selected based on the final size of the molded element and desired porosity (page 5). These parameters have nothing to do with the specific effects of the mixing temperatures used in the present invention, which permit the optimal formation of a fiber cake with the addition of water glass, beyond the fact that both methods require thermal energy. It is not reasonable to think that a person with ordinary skill in the art would look to temperature ranges used in making heat injected molds for optimizing a dry method process to make fiberboard.

In the case of the present invention it is the press time and not the porosity that is effected by the water content. The temperature ranges of 30- 95 °C (claim 1), 40-75 °C (claim 2), and 105-180 °C (claim 4) are optimized to minimize press

time while preserving homogeneous distribution of the water glass in the fiber board. By adding the water glass directly to the blow line, the water content does not exceed 11%. Gath teaches a preferred range of 100-120 °C for a water content of 40% and temperature range of 170-210 °C for a water content of 20-25% (pg 4 para 2). Although the temperature ranges overlap, the parameters do not apply to similar processes and would not be obvious to one of ordinary skill in the art.

With regards to claims 7, 8, 17, and 18, Ljungbo does not teach adding the water glass either before or during defibering or into a transport element of the defibering process. Adding the water glass directly to the blow line during the defibering process has a surprising result that would not have been obvious to one of ordinary skill in the art. Namely, because of the heat in the blow line blending, the ability to bind or the so called tack of the water glass is activated and the water glass does not sediment as one would expect.

With regards to claims 5, 6, 13, 14, 15, and 16, Ljungbo teaches adding 25 parts powdered water glass to 100 parts dry wood fibers. Ljungbo specifically teaches away from using water glass in solution and instead requires a glue powder (pg 1, para 6). The current invention demonstrates that adding liquid water glass during the defibering process has a surprising result that would not have been obvious to one of ordinary skill in the art.

With regards to claims 9 and 19, Ljungbo teaches using a powdered silicate water glass in combination with a powdered filler. Ljungbo specifically teaches away from using water glass in solution and instead requires a glue powder (pg 1, para 6) and a powdered filler (pg 3, para 8). The current invention demonstrates that adding liquid water glass during the defibering process has a surprising result that would not have been obvious to one of ordinary skill in the art.

With regards to claim 10, Ljungbo teaches adding a hardener to the powdered water glass before or after adding the wood fibers.Ljungbo specifically teaches away from using water glass in solution and instead requires a glue powder (pg 1, para 6) and a hardener (pg 2, para 5-6). The current invention demonstrates that adding liquid water glass during the defibering process has a surprising result that would not have been obvious to one of ordinary skill in the art.

With regards to claim 11,12 and 20, Ljungbo does not indicate the use of acid formers or additives that facilitate faster curing. Nurenberger teaches the use of carbon dioxide to harden molded mixtures of wood fibers and water glass to make biodegradable, nontoxic, digestible feed containers for use with animals and plants. Although the reference teaches the use of acid formers, the parameters do not apply to similar processes (biodegradable feed containers are not similar to fire-resistant fiber boards) and would not be obvious to one of ordinary skill in the art.

In view of the foregoing, it is respectfully requested that the application be reconsidered, that claims 1-20 be allowed, and that the application be passed to issue.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

A provisional petition is hereby made for any extension of time necessary for the continued pendency during the life of this application. Please charge any fees for such provisional petition and any deficiencies in fees and credit any overpayment of fees to Attorney's Deposit Account No. 50-2041.

Respectfully submitted,

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PanelGuide

ANNEX 2F

Wet Process Fibreboards

Description

A wood fibre board (fibreboard) is defined as a panel material with a nominal thickness of 1.5mm or greater, manufactured from lignocellulosic fibres with application of heat and/or pressure. This generic product type 'fibreboards' can be classified according to the production process and in this regard there are two classifications:

- Wet process fibreboards
- Dry process fibreboards (MDF)

Dry process fibreboard (MDF) has been covered separately in Annex 2e of PanelGuide.

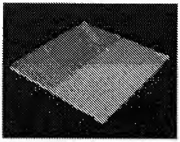
Wet process fibreboards can be classified according to their density:

	Density
Hardboards	$\geq$ 900kg/m^3
Mediumboards*	$\geq$ 400kg/m^3 to <900kg/m^3
Softboards	$\geq$ 230kg/m^3 to <400kg/m^3

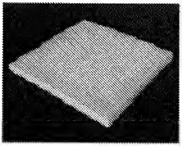
*Mediumboards (which should not be confused with Medium Density Fibreboard – MDF) can be sub-divided into:

Low density mediumboards	400kg/m^3 to <560kg/m^3
High density mediumboards	560kg/m^3 to <900kg/m^3

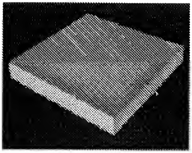
Hardboard



Mediumboard



Softboard



Composition and Manufacture

Wet process fibreboards can be made using either softwood or temperate hardwood species (or both) (some low density mediumboards are made from recycled paper fibre). Wood chips are thermally softened in water and then mechanically refined into fibres. The wet fibres are formed into a mat which is either rolled (softboards), or rolled and then pressed, at a high temperature to the desired thickness. The primary bond is generally derived from the felting together of the fibres and their inherent adhesive properties although in some instances a synthetic adhesive may be added to the fibres. Other additives such as wax, bitumen emulsion, natural oil, fire retardant chemicals may be added.

The differentiating feature between a wet process and dry process fibreboard is that the wet process fibreboards have a fibre moisture content of more than 20% at the forming stage whereas dry process fibreboards have a fibre moisture content of less than 20% at the forming stage and they are produced with the addition of a synthetic resin binder.

Appearance

Hardboard – Surface appearance of hardboards is usually smooth on one side and a fine mesh pattern on the reverse. Duo faced hardboards (smooth both sides) are also available. The colour of boards ranges from light gold to dark brown. Special boards are available including painted, plastic faced, printed with wood grain, embossed/textured (plain, primed or predecorated) and perforated. Enhanced strength and durability characteristics may be imparted by impregnation with hot oil or resin and subsequent heat curing; these panels are usually referred to a tempered hardboard.

Mediumboard – The surface texture is usually smooth on one side with a fine mesh pattern on the reverse. High density mediumboard usually has a hard, shiny surface whereas low density mediumboards have a matt surface. Colour ranges from mid grey to dark brown.

Softboard – The surface texture for unfaced natural panels is open and fibrous. Paper-faced or fine pulp overlaid softboard have smooth or lightly dimpled faces, or a slight mesh pattern on one or both sides. The colour of most boards is various shades of light brown, others are cream or off-white. Some panels are covered with a white primer or bleached pulp for painting. Softboards with enhanced durability and moisture resistance are produced. Currently these enhanced properties are imparted by impregnating the fibres with a bitumen emulsion; a spray coating on one or both surfaces may also be applied. The same characteristics can be imparted with the inclusion of phenolic resins. Typical bitumen impregnated panels are dark brown to black in colour.

Density, Mass and Sheet Size

Board density and the board mass varies according to the product, being affected by the timber species and the process used in manufacture.

Softboard – Densities range typically from 230kg/m^3 to 400kg/m^3. A 2400 x 1200 x 13mm board will weigh approximately 10kg.

Mediumboard – Low Density: Densities vary typically from 400kg/m^3 to 560kg/m^3. A 2400 x 1200 x 6.4mm board will weigh approximately 10kg.

Mediumboard – High Density: Densities vary typically from 560kg/m^3 to 900kg/m^3. A 2400 x 1200 x 6.4mm board will weigh approximately 15kg.

Hardboard – Densities vary typically from 900kg/m^3 to 1100kg/m^3. Thus, for example, a 2400 x 1200 x 3.2mm board will weigh approximately 9kg.

Board Sizes

Board Type	Thickness Range mm	Typical Sizes mm
Hardboard	1.2 – 9.5	1220 x length up to 3660
Mediumboard	6.0 – 12.0	1220 x lengths up to 3660
Softboard	8.0 – 25.0	600 – 1220 x lengths up to 3660

Other sizes are available or can be produced to order.

Applications

Wet process fibreboards find use in a wide range of construction and furniture related applications.

Hardboards

Hardboards are used in furniture as drawer bottoms and unit backs; door facings, caravan interiors, floor coverings as well as being used in shopfitting and display work. Standard hardboard is generally not recommended for exterior use or for use in areas subject to direct wetting or high humidity conditions.

Enhanced performance hardboards can be used for applications where higher strength properties and resistance to abrasion above that of standard hardboard is required. These boards find applications as components within structural members (e.g. I beams) exterior applications such as soffits and signage and for uses in packaging, agriculture and flooring overlays.

Mediumboards

Low density mediumboards have particular application as pinboards and as components of partitioning systems. They can also be found in shopfitting and display applications and as a floor underlay material. High density mediumboards have been used as wall and ceiling lining boards and as a sheathing material in timber frame construction, however, their use today in the UK is limited.

Softboards

Like mediumboards, the range of applications for softboards today has diminished, however, they do find application as pinboards, underlay materials and as an acoustic absorbent. Impregnated softboards are used as a sheathing material in timber frame construction and as a protective overlay in some forms of flat roofing. In pitched roof construction in Scotland impregnated softboards are used as a sarking material and heavily impregnated brands find application as expensive joint fillers.

Specification

Wet Process

Fibreboards manufactured in Europe must now be specified in accordance with European Standards. The UK versions of these are BS EN 622 Parts 1 to 4. As explained in Section 2 of 'PanelGuide', fibreboards that are used in construction must comply (by law) with the requirements of the Construction Products Directive (CPD). The most straightforward route to demonstrating this is by compliance with the harmonised standard for wood-based panels (BS EN 13986). This standard calls up the following parts, relating to wet process fibreboards:

BS EN 622
Part 1: General requirements for al board types
Part 2: Requirements for hardboards
Part 3: Requirements for mediumboards
Part 4: Requirements for softboards

Selection of a grade of board is dependent upon the ambient climatic conditions together with the level of loading that is anticipated. (refer to table below).

Table – Types and grades of wet process wood fibreboard

Board Type	Grade	References
Softboard		
General purpose (for use in dry conditions)	SB	BS EN 622-4
General purpose (for use in humid conditions)	SB.H	
General purpose (for use in exterior conditions)	SB.E	
Load bearing (for use in dry conditions)	SB.LS	
Load bearing (for use in humid conditions)	SB.HLS[a]	
Low density mediumboard		
General purpose (for use in dry conditions)	MBL	BS EN 622-3
General purpose (for use in humid conditions)	MBL.H	
General purpose (for use in exterior conditions)	MBL.E	
High density mediumboard		
General purpose (for use in dry conditions)	MBH	BS EN 622-3
General purpose (for use in humid conditions)	MBH.H	
General purpose (for use in exterior conditions)	MBH.E	
Load bearing (for use in dry conditions)	MBH.LA1	
Heavy duty load bearing (for use in dry conditions)	MBH.LA2	
Load bearing (for use in humid conditions)	MBH.HLS1[a]	
Heavy duty load bearing (for use in humid conditions)	MBH.HLS2[a]	
Hardboard		
General purpose (for use in dry conditions)	HB	BS EN 622-2
General purpose (for use in humid conditions)	HB.H	
General purpose (for use in exterior conditions)	HB.E	
Load bearing (for use in dry conditions)	HB.LA	
Load bearing (for use in humid conditions)	HB.HLA1	
Heavy duty load bearing (for use in humid conditions)	HB.HLA2	
[a] These boards are restricted under humid conditions to instantaneous or short periods of loading		

Guidance on the selection of different grades of fibreboard is given in tabular format of Section 2 of PanelGuide, additional selection guidance is given in DD ENV 12872. The requirements specified in BS EN 622 are not specific to any particular application

Physical Properties

a) Climate

Like other wood-based panel products, fibreboards are hygroscopic and their dimensions change in response to changes in humidity. Typically a 1% change in moisture content results in an equivalent change of 0.4mm per metre in length and width of the board.

As a guide, wood fibreboard can be expected to attain the following moisture content under the following specified conditions.

Relative humidity at 20°C	Approximate equilibrium moisture content
30%	5%
65%	8%
85%	12%

b) Biological Attack

Fibreboards will not normally be attacked by wood boring insects common in a temperate climate. Boards intended for internal uses are susceptible to fungal attack under prolonged wet conditions. Some types of hardboard and bitumen impregnated softboard (>25% impregnation) have been shown to have improved durability against wet rot fungi, over standard grades.

c) Water Vapour Permeability

The value of water vapour resistance factor (μ) for fibreboards varies according to density. Water vapour resistance factors are given as dry cup and wet cup values according to BS EN ISO 12572 "Hygrothermal performance of building materials and products – Determination of water vapour transmission properties". The values given below are extracted from BS EN 13986.

Wood-based panel	Density kg/m^3	Vapour resistance factor	
		Wet cup μ	Dry cup μ
Fibreboard BS EN 622	250	2	5
	400	5	10
	600	12	20
	800	20	30

d) Thermal Conductivity

The thermal conductivity of fibreboards (λ) varies depending on density. The values given below are extracted from BS EN 13986.

Density Kg/m^3	Thermal Conductivity λ W/(m.k)
250	0.05
400	0.07
600	0.10
800	0.14

Reaction to Fire

Under the new Euroclass system for characterising the reaction to fire performance of materials, the following deemed to satisfy rating are given in BS EN 13986:

- Hardboards with a minimum density of 900kg/m^3 and a minimum thickness of 6mm and
- Mediumboards with a minimum density of 600kg/m^3 and a minimum thickness of 9mm

  - may both be assumed to achieve a class D-s2, d0 (excepting floorings) or class D_{FL}-s1 (when used as a flooring) without need for testing, provided that they are used in real applications where they are fixed without an air gap behind, against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3, or at least class D-s2, d0 products with minimum density 400 kg/m^3. **If the manufactured product does not satisfy any of these minimum requirements or is used with an air gap behind, then it must be tested and classified according to BS EN 13501-1.**

- Mediumboards with a minimum density of 400kg/m^3 and a minimum thickness of 9mm
- Softboards with a minimum density of 250kg/m^3 and a minimum thickness of 9mm

  - may both be assumed to achieve a class E,pass (excepting floorings) or class E_{FL} (when used as a flooring) without need for testing, provided that they are used in real applications where they are fixed without an air gap behind, against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3, or at least class D-s2, d0 products with minimum density 400 kg/m^3. **If the manufactured product does not satisfy any of these minimum requirements or is used with an air gap behind, then it must be tested and classified according to BS EN 13501-1.**

Further information on the reaction to fire of the various panel products in both the BS and EN systems is provided in Section 2.2.3.

Storage and Handling

Fibreboards should be stored flat and dry, off the ground, with all four edges flush. Storage in an enclosed building is preferable and external storage should be avoided whenever possible. Stacking on edge should be avoided wherever possible. Panels should be stacked on a close-boarded or slatted pallet, or if this is not possible on battens at no more then 600mm centres. The battens should all be of equal thickness and should be vertically aligned with any others in the same stack, in order to avoid distortion of the panels.

Panels should be protected by a waterproof covering during transport and the edge properly covered. Edges should also be protected against damage by lashings or other banding, this is particularly important for softboards. All boards should be installed at a moisture content as close as possible to that which they will attain in service in order to minimise any movement problems.

Once on site, it is preferable for individual boards to be "stickered" before installation in order to allow air to circulate and to allow the boards to attain a moisture content as close to the final in-service moisture content as possible.

Further guidance on storage and handling can be found in PanelGuide Section 4.

Working with Fibreboards

Fibreboards can be sawn, routed, spindled or drilled. Satisfactory results can be achieved using hand tools, but quicker and more consistent results can be achieved using either portable or fixed power tools.

When cutting wood-based boards it is important to pay attention to normal good practice, sharp cutters, adequate support close to saws and cutters, elimination of machine vibration, correct allowance for saw kerf.

The quality of cut is dependent on the cutter type, tool and material speed and also on the material type and density. Tools must be kept sharp, as dull cutters will cause edges to 'bell'.

Fibreboards can be drilled using all types of wood working drill bits.

Fixing Fibreboards

Hardboards and mediumboards can be fixed with panel pins, nails, staples, and screws; the type used will depend upon the end use. Screws through thinner hardboards should have cups if 'pull through' is a possibility. Hardboard and mediumboard can be bonded with most types of woodworking adhesives. Fixings into hardboard and mediumboard should generally use cavity fittings.

Softboards can be fixed with nails, staples and screws; the type used will depend upon the end use. Nails with large heads are recommended and screws should be fitted with cups. Softboard can be bonded with most types of woodworking adhesive and with bitumen adhesives for applications such as roofing. Due to their low density, softboards will not hold fixings satisfactorily when these are loaded. An appropriate type of cavity fixing which will spread the load should be considered.

Finishing

Fibreboard (except bitumen impregnated fibreboards) provide a suitable substrate for paints, stains, varnishes and textured coverings. Lining materials such as wallpaper, hessian and other fabrics can also be applied providing an appropriate adhesive is used.

Hardboards and mediumboards can be veneered and laminated with high and low pressure laminates, paper and PVC foils.

Some brands of fibreboard are available pre-decorated.

Surface Coatings

Mediumboard and hardboard can be painted with conventional oil and water based paints, applied by spray, brush or roller. Matt, satin or gloss finishes can be obtained. Little preparation of the surface should be required, dust and grease should be removed from the board, if necessary using white spirit.

Panels should have a primer or sealer coat applied, this can be proprietary hardboard sealer or a coat of emulsion paint. Some types of oil treated hardboard (which contain natural or added oils require priming with an aluminium primer or multi-purpose primer.

If panel edges will be visible after completion it may be necessary to seal these with hardboard sealer or with a wood or cellulose filler prior to the application of finish.

Softboard can be painted with conventional oil and water based paints, applied by spray, brush or roller. Matt or satin finishes can be obtained. Panels should be brushed free of dust before decoration commences. No rubbing down of the surface should be required.

Natural and ivory faced panels should have a primer or sealer coat applied, a 50/50 mix of emulsion paint and water is suitable for this purpose. White primed softboards can be painted without using a sealer coat.

If further coating is applied an alkali resisting primer is required and the panel or paint manufacturer's advice should be sought.

If panel edges will be visible after completion it may be necessary to fill these with a wood or cellulose filler prior to the application of finish.

Textured coatings can also be applied, care is needed in detailing panel joints which should be either scrimmed and filled or featured by leaving small gaps between adjacent panels.

Coating manufacturers' recommendations regarding priming of panels should be closely followed. After joint treatment, the paint is applied and textured (stippled, combed etc). The edges are normally finished by using a small brush to produce a plain margin.

Further details concerning cutting, fixing and finishing are given in Section 4 of PanelGuide.

Health and Safety

In common with other wood products, fibreboards are safe when it is handled and used correctly.

When cutting or machining fibreboards, wood dust is produced and as this can be hazardous, measures must be taken to control the dust. This is normally carried out with the use of a suitable personal dust mask or by dust extraction systems in a workshop environment.

Dust from cutting operations can be controlled by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these regulations, wood dust has a Maximum Exposure Limit (MEL) of $5mg/m^2$, which is appropriate to wood dust from the machining of fibreboards. Exposure must be reduced as far as possible below this limit.

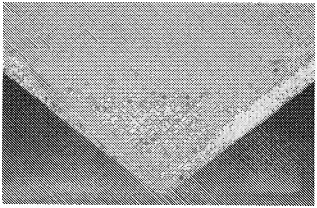
The formaldehyde potential of wet process fibreboards can be considered to be extremely low and may be considered to be within the lowest class specified in European Standards without testing.

As with all wood-based panels, there may be handling hazards and COSHH Regulation 6 requires an assessment to be made, and recorded of health risks associated with wood dust and handling. Common risks and control measures are shown in the table below.

Activity	Hazard	Control
Manual handling of full sheets	Large sheet sizes present a risk of strain or crush injuries if not handled correctly.	Store carefully in uniform stacks on a flat level base. Use mechanical handling equipment. Adopt correct manual handling procedures.
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine and hand • Sawing, routing • Hand assembling machined or sanded components	Wood dust in general (including dust from wood fibreboards) may cause dermatitis and allergic respiratory effects. Wood dust is flammable.	Off-site: preparation under exhaust ventilated plant. On-site: enclosure and exhaust ventilation. Dust extraction on portable tools. Good ventilation. Respiratory protection equipment. *Note:* Any health hazards arising from the use of wood fibreboards at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health Regulations 2002.

ANNEX 2E

Dry Process Fibreboards (MDF)



Description

Dry process fibreboards are engineered wood-based sheet materials made by bonding together wood fibres with a synthetic resin adhesive. The term 'dry process fibreboards' is a generic term so called by virtue of the manufacturing process.

Within this description, the most common class of board is Medium Density Fibreboard (MDF) although this in itself is a generic class, which can, for marketing purposes, sub-divided into panel types differentiated principally by their density, i.e.

High Density MDF (HDF)
Low Density MDF (LDF)
Ultra Low Density MDF (ULDF)

Since 1966 when the first MDF was produced commercially in Deposit, New York State, USA, the market for MDF has increased dramatically world-wide. The first MDF was produced in Europe in 1973 and today European production capacity rivals that in the USA, exceeding 12 million cubic metres per annum in 2004.

Because of its availability in a wide range of thicknesses and the ability to be machined and finished to a high standard, dry process fibreboards have been accepted in a wide range of applications both in construction and also furniture, where in both cases it has substituted solid timber and also other wood-based panels in particular applications.

The development of value added variants with enhanced mechanical performance and improved performance in the presence of moisture and fire have further aided the applications available.

MDF can be manufactured with either softwood or hardwood species. The majority of MDF manufactured is composed mainly of softwood although some individual brands may contain a higher percentage of temperate hardwood depending on the location of the factory to the local forest resource.

The constituents of a typical standard MDF manufactured in the United Kingdom or Ireland are 82 virgin wood fibre (wholly or mainly softwood), 10% synthetic resin binder, 7% water, less than 1% paraffin wax solids and less than 0.05% silicon. The most common binder is urea-formaldehyde although depending on the grade and end use of the product other binders may be used, i.e. melamine urea-formaldehyde, phenolic resins and polymeric methylene di-isocyonate (PMDI).

A typical process involves reducing wood down to small chips, which are then thermally softened and mechanically refined into fibres, which are then mixed with a synthetic resin binder. The resinated fibres are dried and then formed into a mattress ready for pressing. The mattress is pressed between heated polished press plates to the desired thickness. For thick boards more than one mattress may be 'piggy backed' together.

Appearance

MDF has smooth sanded surfaces, it has a homogeneous construction and is typically pale straw in colour. For identification purposes the whole panel, i.e. individual layers of the panel may be dyed according to industry practices (e.g. green for panels with enhanced moisture resistance, or red for panels integrally treated with flame-retardant chemicals). Integral colouring is distinct from the voluntary coloured stripe system that may be applied on the outside edge of panels in a pack, at opposite corners to identify particular grades in accordance with EN standards The presence of an integral colour does not guarantee that enhanced properties are present, and reference should be made to panel markings or manufacturer's literature to verify this.

Density, Mass and Sheet Size

Standard forms of MDF have densities as follows:

Average density:	700 - 800kg/m^3
Core density:	600 - 700kg/m^3
Face density:	1000 - 1100kg/m^3

These are now considered to be part of a wide range of dry-process fibreboards with the following densities.

High Density MDF (HDF):	Above 800kg/m^3
Light MDF (LDF):	Below 650kg/m^3
Ultra-Light MDF (ULDF):	Below 550kg/m^3

Due to variation between brands, the weight of MDF is not constantly proportional to thickness. Typical weights, based on standard MDF with average density 750kg/m^3, are:

Thickness	Mass per Unit Area
6.5mm	5.0kg/m^2
9.0mm	6.3kg/m^2
12.0mm	8.4kg/m^2
16.0mm	11.0kg/m^2
19.0mm	14.0kg/m^2

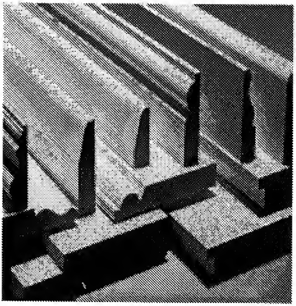
MDF is available in an extensive range of thicknesses, i.e. 1.8mm to 60mm. The most common sheet sizes are: widths 1220mm, 1525mm and 1850mm and in lengths up to 3660mm.

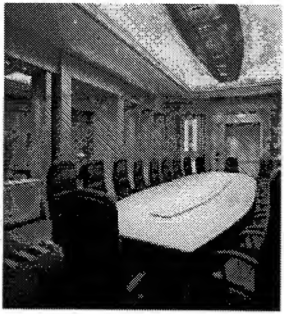
Other sizes are available or can be produced to order (minimum order conditions exist).

With the exception of the largest users such as volume furniture manufacturers, MDF in common with other wood-based panels would generally not be supplied direct by the manufacturer but instead, depending on the volume and specification, could be supplied through a distributor or merchant.

Applications

Due to the particular machining and finishing attributes combined with good working properties and its availability in a wide range of sheet thicknesses and sizes, MDF finds application in a wide range of construction and furniture applications. It is used increasingly for interior design and building applications such as skirtings and architraves, windowboards, wall linings, and decorative facades, as well as the core material for some floorings.





MDF can be cut without breakout or splintering and it can be profiled on the edges and surfaces. The smooth and relatively dense surface provides an excellent base for painting, veneering and laminating. Consequently MDF is used extensively in furniture production, and with the range of value added variants, its use is being extended into shopfitting and display, interior fitments, exterior application (e.g. signage and shop fronts) as well as components within numerous other products.

Specification

MDF manufactured in Europe for use in construction must be specified in accordance with European Standards. The UK versions of these are BS EN 622 Part 1 and BS EN 622 Part 5. As explained in Section 2 of 'PanelGuide', MDF that is used in construction must comply (by law) with the Construction Products Directive, and the most straightforward route to achieving this is by complying with the Harmonised Standard for wood-based panels (BS EN 13986 – "Wood-based Panels for Use in Construction – Characteristics, Evaluation of Conformity and Markings"; this standard calls up Parts 1 and 5 of BS EN 622 . These are:

BS EN 622
Part 1 – General requirements for all fibreboards
Part 5 – Requirements for dry process boards (MDF)

Selection of a particular grade is dependent upon the ambient climatic conditions together with the level of loading that is anticipated.

The requirements given in BS EN 622-5 are not specific to any particular application and so it is appropriate to refer to Codes of Practice or manufacturers literature when considering a particular application (Refer to Sections 2 and 3 of PanelGuide).

For construction applications some selection guidance is given in DD ENV 12872.

The specifications classify boards according to their intended end use classification.

MDF Type	Use Classification*
MDF	General Purpose – Dry
MDF.H	General Purpose – Humid
MDF.LA	Load Bearing – Dry
MDF. HLS	Load bearing – Humid**

* Defined in BS EN 622-5

** These panels are restricted under humid conditions to instantaneous or short periods of loading.

BS EN 622-5 is currently being revised and the new version is likely to include both light and ultra-light grades as well as an underlayment grade of MDF.

BS EN 622-1 specifies some properties that are common to all uncoated fibreboards, i.e. dimensional tolerance, moisture content and formaldehyde potential.

BS EN 622-5 specifies properties for each type of MDF grade: swelling in thickness, internal bond, bending strength and modulus of elasticity (not design values). In addition supplementary properties which may be specified are identified although no values are given, i.e. surface soundness, axial withdrawal of screws, surface absorption and dimensional changes. Panel manufacturers generally provide values for these properties.

Physical Properties

a) Climate

Like other wood-based panel products, MDF is hygroscopic and its dimensions change in response to a change in humidity. Typically a 1% change in moisture content increases or decreases the length and width by 0.4mm per metre run.

As a guide, MDF could be expected to attain the following moisture content under the specific conditions.

Relative Humidity at 20°C	Approximate Equilibrium Moisture Content
30%	5%
65%	8%
85%	12%

When components are factory produced for installation on site it is essential that the site conditions are suitable to receive the components, with wet trades completed and the building dried out.

Panels with enhanced moisture resistance are not waterproof; the term "moisture resistant'" applies to the adhesive binder which (within limits defined by BS EN 622-5 will not break down in the presence of moisture). Physical wetting of all grades of MDF should be avoided.

b) Biological attack

MDF will not normally be attacked by wood-boring insects common in temperate climates, but is susceptible to fungal attack under prolonged wet conditions.

c) Water Vapour Permeability

The value of the water vapour resistance factor (μ) for MDF varies from a value of 2 at a density of 250kg/m^3 to 20 at a density of 800kg/m^3,when tested in accordance with BS EN ISO 12572, using test conditions C (the wet cup method) Dry cup values vary from 5 at a density of 250kg/m^3 to 30 at a density of 800kg/m^3. Values for various densities of fibreboard are given in Table 9 of BS EN 13986.

d) Thermal Conductivity

The thermal conductivity (λ) of MDF varies from 0.05 W/mK for a panel density of 250kg/m^3 to 0.14 W/mK for a panel density of 800kg/m^3. Values for various densities of fibreboard can be found in Table 11 of BS EN 13986.

e) Reaction to Fire

Under the new Euroclass system for characterising the reaction to fire performance of materials, an untreated MDF may be assumed to achieve a class D-s2, d0 (excepting floorings) or class D_{FL}-s1 (when used as a flooring) without need for testing, provided that it has a minimum density of 600 kg/m^3, a minimum thickness of 9mm and is used in real applications where it is fixed without an air gap behind, against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3, or at least class D-s2, d0 products with minimum density 400 kg/m^3. **If the manufactured product does not satisfy any of these minimum requirements or is used with an air gap behind, then it must be tested and classified according to BS EN 13501-1**.

Further information on the reaction to fire of the various panels products in both the BS and EN systems is provided in Section 2.2.3.

Storage and Handling

MDF should be stored flat and dry, off the ground, with all four edges flush. Storage in an enclosed building is preferable and external storage should be avoided whenever possible. Stacking on edge should be avoided wherever possible. Panels should be stacked on a close-boarded or slatted pallet, or if this is not possible on battens at no more than 600mm centres. The battens should all be of equal thickness and should be vertically aligned with any others in the same stack, in order to avoid distortion of the panels.

Panels should be protected by a waterproof covering during transport and the edges properly covered. Edges should also be protected against damage by lashings or other banding, this is particularly important for panels with profiled edges e.g. tongued and grooved panels. It is particularly important that panels are protected from wetting during storage and construction. "Humid" panels can tolerate inflated humidity conditions such as can be found in kitchens and bathrooms but direct contact with water should be avoided with the unprotected panel. All panels should be installed at a moisture content as close as possible to that which they will attain in service, in order to minimise any movement problems.

Once on site, it is preferable for individual panels to be "stickered" before installation in order to allow air to circulate and to allow the panels to attain a moisture content as close to their final in-service moisture content as possible.

Further guidance on storage and handling can be found in PanelGuide Section 4.

Working with MDF

Satisfactory results can be achieved using hand tools but quicker and more consistent results can be achieved using either portable or fixed power tools.

Tungsten carbide tipped (TCT) tools will give better cutting performance on power tools.

Where material routing and moulding is required, the cutter type, tool and material feed speed all affect the quality of finish, cutters must be kept sharp, as dull cutters will cause edges to 'bell'. Whilst all MDF generally machines well, the density profile will differ between brands and this may influence the quality of finish.

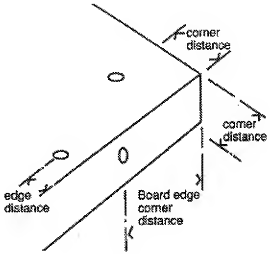
MDF can be drilled using all types of wood working drill bits.

Fixing MDF

MDF can be fixed using all conventional woodworking fixings and techniques. It provides good holding power for screw fixings into board faces and edges. Parallel core screws should be used because they have greater holding powerthan conventional wood screws. Typical screw withdrawal values tested to BS EN 320 are:

Face: 1050N
Edge: 850N

A high overall diameter-to-core diameter ratio is desirable. Nails and staples can be used for lightly loaded fixings or to hold glued joints while adhesive sets.



Drill pilot holes for screw fixing. Typically, the holes should be 85 to 90% of the screw core diameter. Fixings into the panel face should not be within 12mm of edges and 25mm of corners. Screws into the panel edge should not be within 70mm of corners.

MDF can be bonded with all types of woodworking adhesive. The appropriate type depends on end use.

Dowel joints can be satisfactorily used with MDF. Multi-grooved dowels are recommended. Dowels and holes should have an interference fit, that is of such size that the dowel can be pushed home by hand but, even without adhesive, is not sufficiently loose that it can fall out. Allow some tolerance on the dowel diameter, typically up to 0.2mm oversize.

Mechanical joints and fixing

Mechanical fittings can be applied to MDF with the following recommendations:

Wherever possible, select fittings that depend upon face fixing. Avoid fittings that depend upon the expansion of a component inserted into the board edge.

When using screws, use recommended pilot hole dimensions.

When fixing MDF as wall panelling or cladding, it is important to leave a small expansion gap between adjacent panels. The gap should be 2.5mm per metre minimum; often a feature gap is used, for example 10 or 12mm, with or without coverstrip.

Adhesive-bonded joints

A wide variety of jointing methods can be used, provided the following simple guidelines are observed:

- The joint parts should be accurately machined.
- Use sharp cutters to avoid tearing or burnishing the surfaces to be bonded.
- Use a high solids content adhesive with low flowing properties (polyvinyl acetate or urea formaldehyde).
- Locate mating pieces accurately and hold them under pressure while the adhesive sets.
- The width of grooves machined in MDF should be limited to about one-third of the thickness of the panel. The depth of groove should be about one-half of the panel thickness.
- Allow adhesive-bonded joints to condition for several days before sanding and finishing; this avoids the appearance of sunken joints and is essential with high-gloss finishes.
- A tongue and groove joint is very efficient, provided the fit of the joints is not too tight to cause a split along the edge.
- When attaching lippings, the tongue should be machined on the solid wood piece.

Finishing

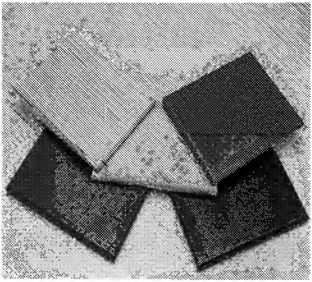
Sanding

The faces of MDF are usually pre-sanded by manufacturers with 120 grit abrasive. This provides a smooth surface ideally suited to the direct application of most veneers and plastic foils. Scuff sanding with the objective of increasing adhesion may be detrimental. For the economic application of paints or printed effects and for very thin foils a further light sanding with 200 grit abrasive may be advisable. Excessive sanding of the faces should be unnecessary and because it could unbalance some MDF boards it should be avoided.

Silicone carbide based abrasives are generally recommended for sanding MDF, Aluminium oxide abrasives tend to dull rapidly, producing burnishing. A 'modified close coat' abrasive is suggested. High sanding speeds cut the most efficiently; for example, with belt sanders, belt speeds in excess of 1500 metres per minute are recommended.

Sanding after moulding or routing produces a smoother surface, moulded edges can be sanded using a profiled sander. 80/100 grit abrasives should be used to remove cutter marks, 120/150 grit is required for finish sanding.

Surface Coatings



MDF can be finished with a wide range of coatings.

Because the edges of MDF are more absorbent than the surfaces, they may require sealing with shellac, polyurethane, diluted PVAC, or specially formulated, high solid content sealers; these compensate for their greater absorption.

Opaque paints are the easiest finishes to apply as their high solids content allows a high build. A base coat and a finish coat are usually all that is required.

Pigmented systems can produce single colour finishes; more specialised techniques and lacquers can produce metallic, marbled and other finishes.

Conventional oil or water-based paints give good results; better and quicker results can be achieved using lacquers based on nitrocellulose, acid catalysed resins, polyurethane or polyester resins applied by hand spray.

High-gloss finishes can be obtained using a high-build coating based on polyester resins, possibly with a clear lacquer top coat to protect the surface and enhance the gloss effect.

Clear lacquers and varnishes can be used. Application and preparation is similar to that for pigmented finishes. When coloured translucent finishes are required, decorative stain finishes can be used. Solvent-borne stains will wet the surface effectively and ensure an even colour; water-borne stains can be used but the waxes added to MDF to reduce water absorption may result in uneven absorption of stain and consequent colour variation. One or two coats of clear lacquer can protect stained surfaces. As the edges of MDF are more absorbent that the surfaces, stain finishes applied to edges may result in darker colours compared to surfaces.

Depending upon the finishing system used, it may be necessary to sand between coats using a fine-grit paper. Water-based systems in particular tend to raise the fibres.

Health & Safety

In sheet or processed form MDF does not present any health or safety risk. Contact with wood products can cause irritation effects but the most significant risks come from mishandling the material.

Very fine dust is produced when MDF is machined. Just like any other wood dust, this is a potentially hazardous substance and it must be controlled. There is no evidence that exposure produces health effects that are different in nature to those associated with exposure to similar levels of dust from other wood sources.

Dust from cutting operations can be controlled adequately by complying with the Control of Substances Hazardous to Health (COSHH) Regulations 2002. Under these regulations,

wood dust has a Maximum Exposure Limit (MEL) of $5mg/m^3$, this is the relevant limit for controlling exposure to MDF dust.

Exposure must be reduced as far as possible below this limit, usually with properly designed and maintained dust extraction equipment fitted to woodworking machines.

Extraction equipment is often not practicable or even available when using portable or hand-held tools, so wear a suitable dust mask (for example, Type FFP2 to BS EN 149). If possible, machine MDF in a well-ventilated place.

Formaldehyde in the workplace atmosphere has an MEL of 2 parts per million (ppm). However, studies indicate that anyone machining MDF in typical situations is exposed to levels of free Formaldehyde significantly below this.

Two formaldehyde classes (determined in accordance with BS EN 120, BS EN 717-1 and BS EN 717-2) are specified in the "Harmonised Standard" (BS EN 13986) at a moisture content of 6.5%.

Based on BS EN 120, the limits are set at:

Class E1 $\leq$ 8mg/100g
Class E2 > to $\leq$ 30mg/100g

MDF manufactured in the UK and Ireland has Class E1 formaldehyde content.

Hazards and control

In sheet or processed form, MDF is non-classifiable under the COSHH regulations. However, there may be handling hazards.

COSHH Regulation 6 requires an assessment to be made (and normally recorded) of health risks associated with wood dust or formaldehyde together with any action needed to prevent or control those hazards.

The table below gives the most common hazards and identifies control methods to minimise the risk of harm actually occurring.

Common hazards and methods of control

Activity	Hazard	Control
Manual handling (in full sheet form)	Large sheet sizes present a risk of strain or crush injuries if not handled correctly.	Store carefully in uniform stacks on a flat level base. Use mechanical handling equipment. Adopt correct manual handling procedures
Carpentry work Activities likely to produce high dust levels include: • Sanding by machine & hand • Sawing, routing & turning • Hand assembling machined or sanded components	Wood dust in general (including dust from MDF) may cause dermatitis and allergic respiratory effects. Wood dust is flammable.	Off site: preparation under exhaust ventilated plant. On site: enclose and exhaust ventilation. Dust extraction on portable tools. Good ventilation. Respiratory protection equipment. *Note*: Any health hazards arising from the use of MDF at work can and should be controlled by compliance with the requirements of the Control of Substances Hazardous to Health (COSHH) Regulations 2002

MDF Safety Concerns

In 1997 questions were voiced through the media as to the safety of MDF. In relation to speculation the Health and Safety Executive embarked on an 18 month investigation into the health effects of MDF.

The results of this investigation were reported on the 6 December 1999 and the following is an extract from the HSE Press Release.

"The Hazard Assessment Document for MDF reports on the scientific evidence for the possible health effects of exposures arising from machining MDF and includes information from the HSE commissioned research on the atmosphere created during the machining of MDF,

> *"The Hazard Assessment Document was discussed by the Advisory Committee on Toxic Substances' Scientific Sub-Group, the Working Group on the Assessment of Toxic Chemicals (WATCH). These committees provided a forum where both the trade unions and industry were able to present their views on the work that was taking place.*
>
> *WATCH endorsed the conclusion of the hazard assessment that there is no evidence of any different ill-health effects associated with exposure arising from the machining of MDF to those associated with similar exposure arising from machining other forms of wood.*
>
> *In respect of occupational exposure, WATCH expressed the view that the most appropriate risk management strategy for MDF is the one currently recommended by HSE. This specifies that the level of dust arising from the machining of MDF should be kept to as low as reasonably practicable below the Maximum Exposure Limits (MELs) for softwood dust and hardwood dust and that levels of free formaldehyde should be kept as low as reasonably*

practicable below the MELs for formaldehyde. Softwood and hardwood dusts each have an 8-hour time weighted average MEL of 5mg/m^3 (total inhalable dust, whilst formaldehyde has MELs of 2 ppm, as an 8-hour time weighted average and as a 15 minute short term exposure limit.

Based on current available evidence, the HSE's view is that any health risks that might arise from the use of MDF at work can and should be controlled (in common with many other substances) by compliance with the Control of Substances Hazardous to Health (COSHH) regulations"

In respect of DIY exposure, the Medical Research Council's Institute for Environment and Health (MRC) is on record as saying "Looking at the domestic situation, available evidence suggests that DIY exposure to wood dust (through cutting, sawing, sanding, etc) is unlikely to pose any measurable health risk", and added that "While MDF (because of its composition) is likely to produce more fine dust than solid wood for the same operations, it is – as with wood – considered unlikely to pose any significant hazard".

In respect of actual dust exposure levels in the home arising from DIY activity the MRC opinion is that it seems unlikely that such activities would give rise to total dust exposures remotely approaching those seen in occupational settings.

The MRC recommended that during DIY activities, care should be taken when working on MDF so as not to liberate or inhale dust, an appropriate facemask should be worn.